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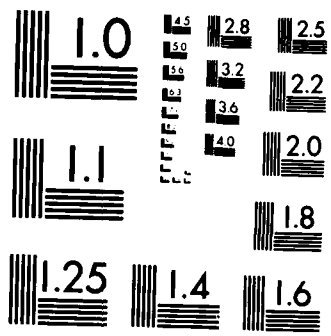
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BLAST TRAUMA: THE EFFECTS ON HEARING

ANNUAL SUMMARY REPORT
August 1, 1980 - July 31, 1981

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Dr. Donald Henderson
Dr. Richard Salvi

April 1981

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This project will determine what effects impulse noise (blast trauma) has on hearing performance, the response patterns of auditory nerve fibers and the morphology of the cochlea. Initially, audiograms and psychophysical tuning curves of the normal chinchilla will be measured; then the animals will be exposed to impulse noise. Afterwards, the psychophysical measures will be repeated in order to evaluate the changes in hearing performance. Microelectrode techniques will be used to sample the thresholds and tuning curves of single VIII nerve fibers and the neural results will then be compared

with the behavioral data. Finally, the cochleas of the noise exposed animals will be embedded in plastic and dissected out for light and electron microscopic analysis; cochleograms will be prepared and damage to cilia and supporting structure will be noted.

The purpose of this study is to determine how various cochlear pathologies induced by impulse noise influence neural and behavioral measure of theshold and frequency selectivity.

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FOREWORD

In conducting the research described in this report, the investigator(s) adhered to the "Guide for Laboratory Animal Facilities and Care," as promulgated by the Committee on the Guide for Laboratory Animal Resources, National Academy of Sciences-National Research Council.

Introduction: The intense noise levels frequently encountered in military environments constitute a serious hazard to hearing. This is particularly true of blast waves which have extremely high peak intensities. The hearing loss resulting from blast wave exposures are highly variable, consequently it is extremely difficult to predict the amount of hearing loss resulting from a specific exposure. Furthermore, there does not appear to be a strict relationship between the degree of hearing loss and amount of hair cell loss in the cochlea (2,5,4). One major problem in determining the safe levels of impulse noise is that we do not have a clear understanding of how impulse noise damages the inner ear. The purpose of this project is to develop a better understanding of the basic mechanisms underlying hearing loss induced by impulse noise. The project entails: (1) Measuring the normal hearing performance of the chinchilla (thresholds, psychophysical tuning curves and masked thresholds) and then exposing the animals to impulse noise in order to create a variety of cochlear pathologies. After exposure, the psychophysical measures are retaken to assess the effects of noise on hearing; (2) Then, the chinchillas are prepared for physiological recordings and the thresholds and tuning curves of single auditory nerve fibers are measured; (3) Finally, the cochleas are fixed, embedded in plastic and the histopathologies are analyzed by light and electron microscopy. Afterwards, the changes in hearing performance will be compared with alterations in neural activity and with the cochlear histopathologies.

Pre-exposure Psychophysical Measurements: Exposure to intense noise is known to affect the sensitivity and frequency selectivity of the auditory system. What is not known, however, is how these measures correlate with the underlying neural activity and cochlear histopathologies. The first step of this project is to use avoidance conditioning procedures (1), to measure the thresholds and psychophysical tuning curves of the chinchilla. At this time we have eight chinchillas undergoing the psychophysical measurements and several animals are near the end of their pre-exposure tests. The behavioral threshold of the animals are measured at pure tone frequencies between 0.25 to 16 kHz using 500 and 20 ms tone bursts. The thresholds of the animals were comparable to those in earlier reports (7,1).

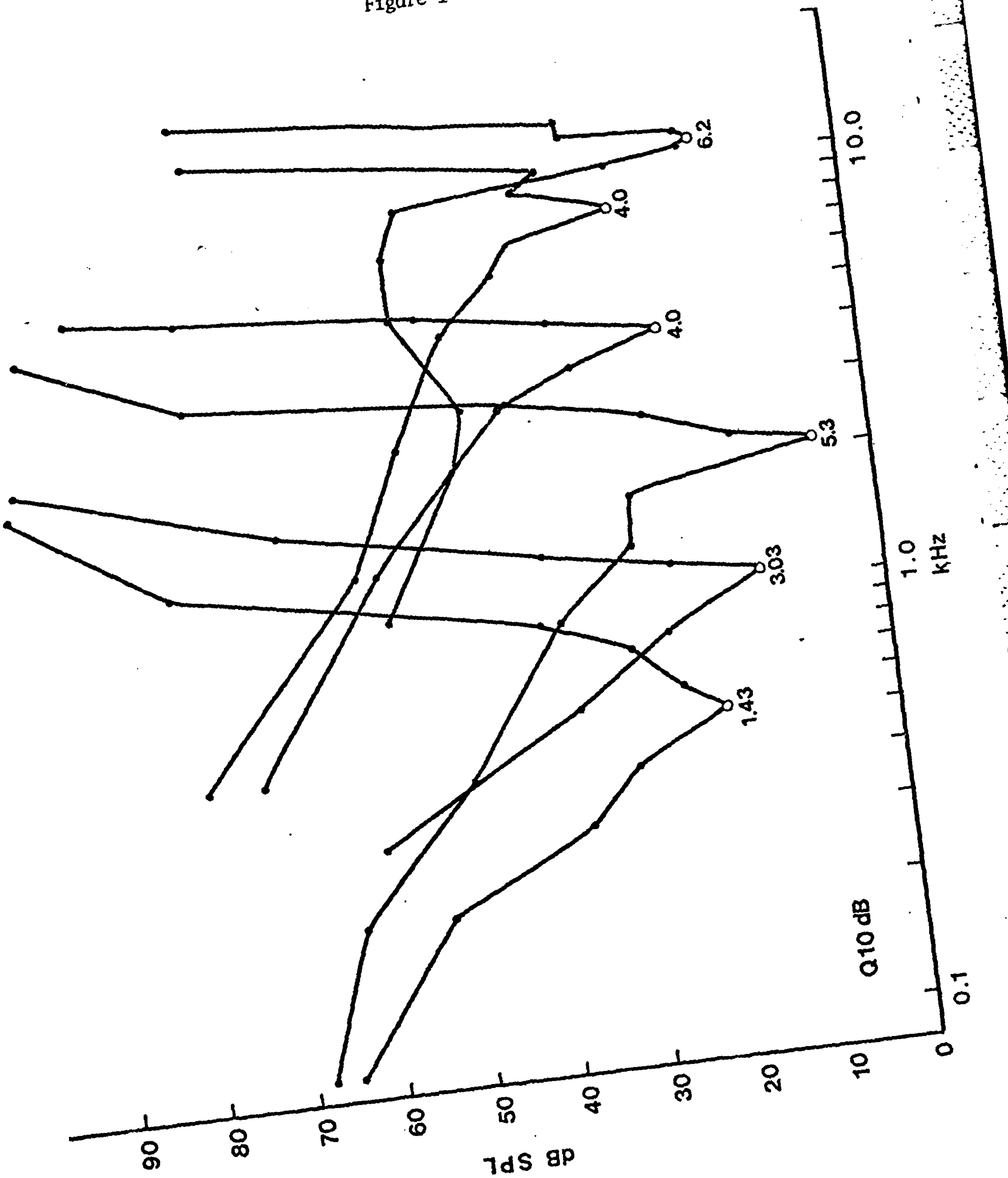
A much more difficult listening task for the chinchilla to perform is to detect a brief probe tone (20 ms) in the presence of a continuous masking tone. The masking tone is varied in level until it just prevents the detection of the probe. When this procedure is carried out over a range of masking frequencies, one obtains a "V" shaped function (masker level vs. masker frequency) at each probe frequency; This is referred to as a psychophysical tuning curve (PTC).

We have chosen to obtain PTC's with simultaneous masking procedures rather than forward masking in order to simplify the listening task for the chinchilla. Although there are differences between forward and simultaneous masked PTC's (9), the differences appear to be

Figure 1

Representative pre-exposure psychophysical tuning curves obtained from one chinchilla. Probe tone frequencies are indicated by open circles and Q_{10} dB values are indicated below the tip of the tuning curve.

Figure 1


6.2
4.0
4.0
5.3
3.03
1.43
Q10 dB
10.0
1.0
0.1
kHz
0
10
20
30
40
50
60
70
80
90
dB SPL

insignificant for data obtained from the chinchilla (6). Figure 1 shows six PTC's obtained from one representative chinchilla. The PTC's obtained at or above 2 kHz have a low threshold, narrowly tuned region near the probe or tip of the PTC. The depth of the tip is roughly 25-40 dB. One common characteristic of high frequency PTC's is the rather abrupt transition between the tip and tail of the PTC; the effect is especially noticeable for the PTC obtained at 11.2 kHz. In most cases, the threshold difference between the tip and tail was on the order of 25 to 40 dB. The high threshold, broadly tuned tails give the high frequency PTC's their asymmetric V-shaped appearance.

Below 2 kHz, the PTC's take on a nearly symmetrical "V" shaped appearance due to the lack of a distinct tail region. Furthermore, the tuning curves become broader than at high probe frequencies. One useful quantitative measure of the degree of frequency selectivity is Q_{10} dB value, i.e., the center frequency of the tuning curve divided by its bandwidth 10 dB above the tip of the tuning curve. As shown in Figure 1, the Q_{10} dB values of the PTC's decrease from a high of 6.2 at 11.2 kHz to a low of 1.43 at 0.5 kHz.

In summary, the pre-exposure PTC's from the chinchilla have the same general shape as those obtained from human listeners (9), and are similar to the neural tuning curves from the chinchilla (8). Within the next few months, these animals will be exposed to impulse noise. Approximately 30-90 days after exposure their thresholds and PTC's will be remeasured to determine the effects of the blast wave exposure on hearing.

Noise Exposures: In order to obtain some insights on the potential anatomical changes that may be found in the behaviorally trained animals, two additional groups of chinchillas have been exposed to the blast waves that will be used in later experiments. The impulses were A duration Frielander waves. Thirteen animals were exposed to 50 impulses (1/minute) having a peak SPL of 160 dB and a duration of 1-2 ms. These two groups of animals will be sacrificed within the next two weeks and their cochleas will be fixed, embedded in plastic and analyzed by light microscopy and surface preparation techniques. If regions of the cochlea look interesting from the surface preparation view, the areas will be sectioned in various planes and then analyzed further by light and electron microscopy.

The two impulse levels used above contain considerable low frequency energy with a peak in the spectrum below 100 Hz. Based on earlier work (3), we expect to find some cochleas with extensive OHC and/or IHC losses in the mid frequency region and some cochleas with diffuse hair cell losses throughout the cochlea. In addition to hair cell losses, impulse noise exposures can produce a variety of histopathologies in the supporting cells of the cochlea which may lead to interesting physiological and/or psychophysical changes.

Technical Developments: The proposal for this project was originally submitted from Syracuse University and then later resubmitted from the University of Texas at Dallas (UTD) because the three authors accepted faculty positions there. Consequently, the laboratories had to be dismantled and then reassembled at the University of Texas at Dallas. Because of renovations at UTD, there was a delay of several months before the conditioning equipment was completely set up and calibrated and animals surgically prepared. At the present time, all of the equipment for conditioning animals, generating and measuring blast waves and preparing the histological materials is available and in working order. The single unit physiology lab, however, is not yet at its full capabilities. The major reason for the delay in this area is that we were not allowed to transfer our computer system from Syracuse; consequently we had to purchase a new computer system and peripherals and then develop software all of which created a substantial delay. We expect to have the physiology lab operational about the time that the post-exposure psychophysical tests are completed on the first group of animals. Considering the difficulties of reestablishing the laboratory, we feel that we have made substantial accomplishments on this project over the past eight months.

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